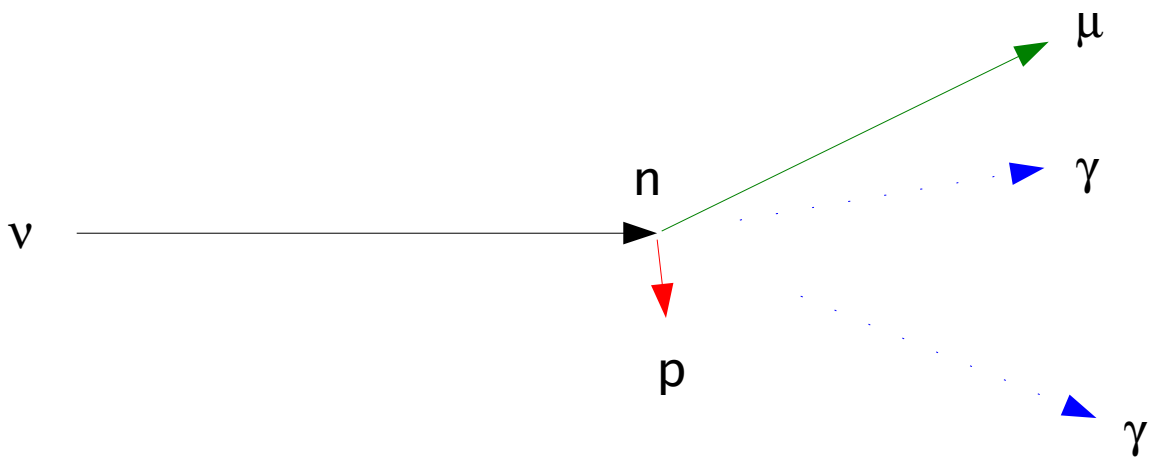
CCπ^0 analysis



Robert Nelson

2009.04.03

Intro

- Brief explanation of the fitter
- Effective CCπ^0
- Selection cuts
- Kinematic distributions
- Future
- NUINT09

The CCπ^0 fitter

- Assume that the one-track muon fit points at a ring on the wall.
- Scan for a second ring using a muon hypothesis.
  - Perform a two-track fit.
- Scan for a third ring using a muon hypothesis.
  - Perform a three-track fit.
- Swap out two muons for two photons in the three possible configurations and fit each case.
- Choose the "best" case and perform an `improve` fit.
  - Can use the raw likelihoods to choose.
  - Or use the event vertex to michel vertex direction as a penalty.
- The result is the final fit.

- MC is `may07_allhad`.
- Data and MC may have different pre-cuts.
  - They will be rerun as soon as we freeze the fitter.
  - Both have hard fiducial volume cuts to help alleviate this possible issue.
- All histograms are normalized to the fiducial cut total histograms.
  - Plots with cuts then have the same scale as the totals.
- This fitter has chosen to improve our μ finding ability, at a slight cost to the π^0 kinematics.
  - Chances are we might use events only where both fits agree.
- Fiducial cuts are:
  - Standard tank and veto hits.
  - 1-track muon radius < 550 cm.
  - 3-track final fit radius < 500 cm.
  - CCπ^0 selection cuts (not really fiducial, just labeled that way on plots).

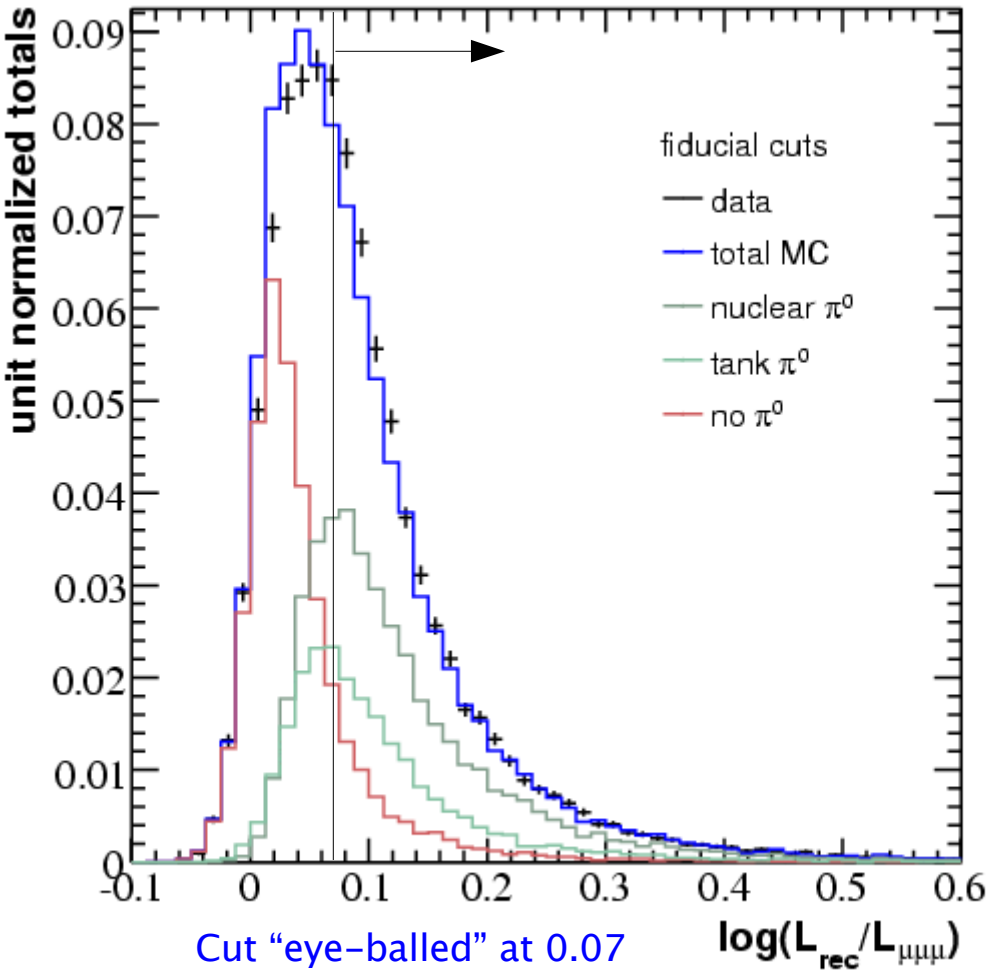
Note:

Effective CCπ^0

- Are defined to be charge-current muon events with a π^0 that exits the nucleus.
  - Includes all experimentally irreducible backgrounds to a true CCπ^0 measurement.
  - This is what we will call our signal.
  - This includes about half of the charge exchanged CCπ^+ events that pass pre-cuts.
- Tank π^0 are all other events that have π^0 that are not from the nucleus.

Separating out non-effectives

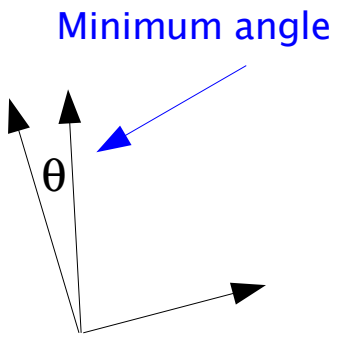
- L_{rec} is the assumption that event is a μ and 2 γ from a common vertex.
- $L_{\mu\mu\mu}$ are for 3 μ from a common vertex.
- We do not have an effective CCπ^0 likelihood.
- The fact that data and MC do not agree perfectly means that we need to study the biases involved when performing this cut. Same is true for the next cut.

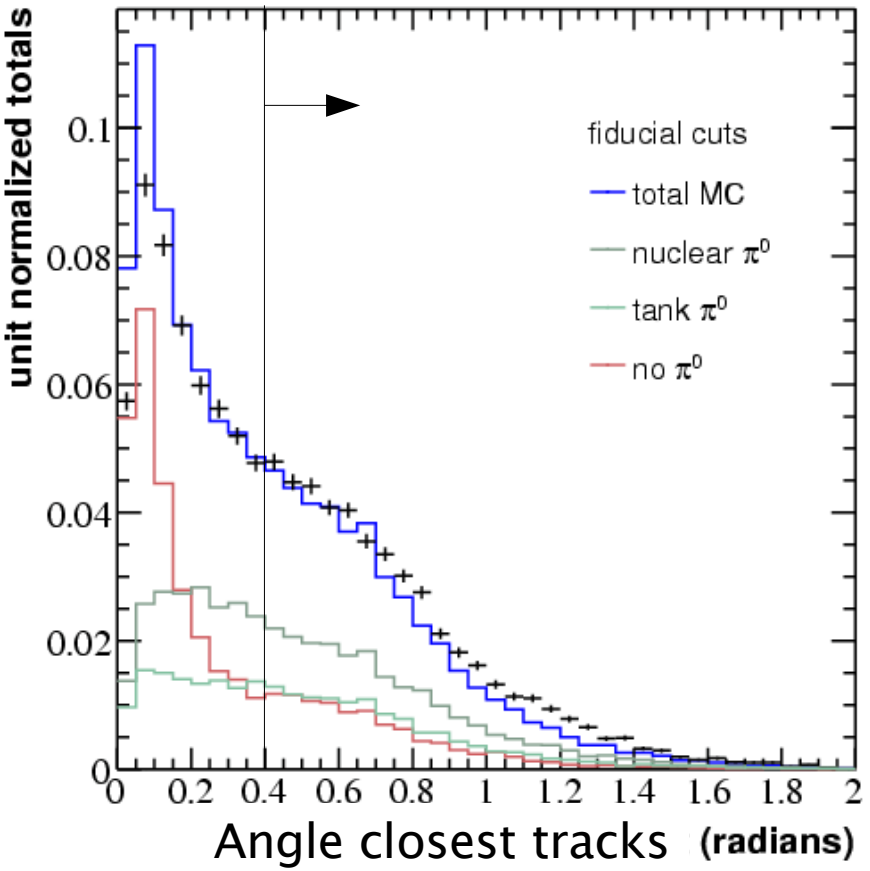


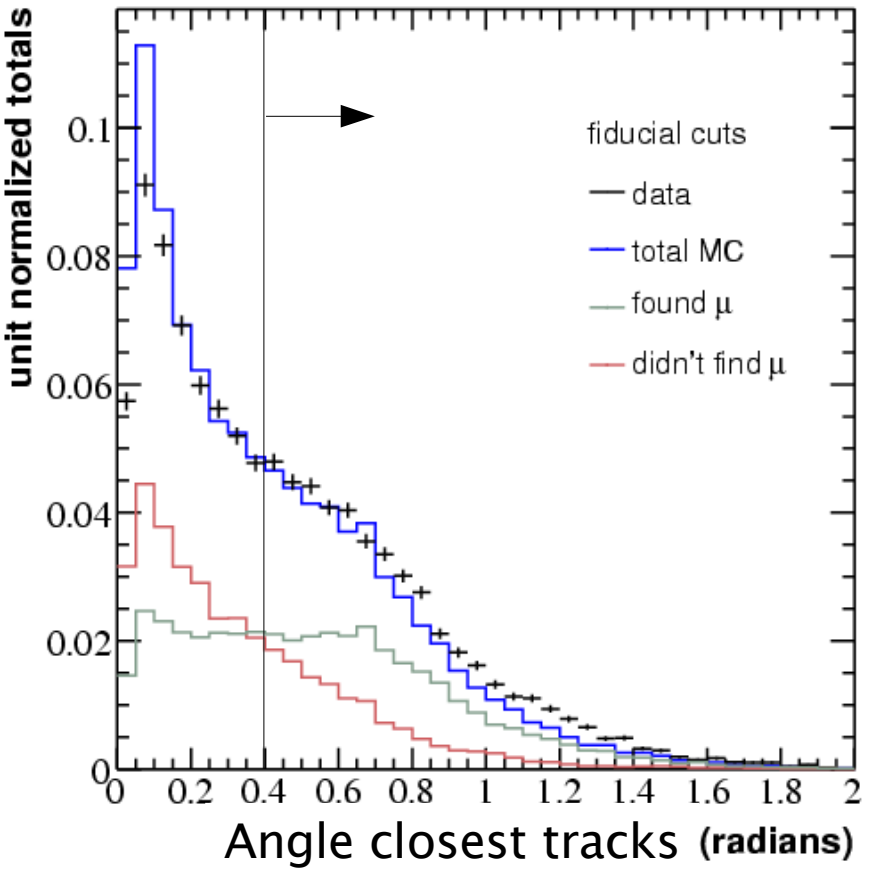
Cut "eye-balled" at 0.07

Separating out mis-reconstruction

- There are not any physics reasons for tracks to land on one another.
- Cutting these events removes events where we can not distinguish the difference between two rings.
- Again, we need to worry about biases.

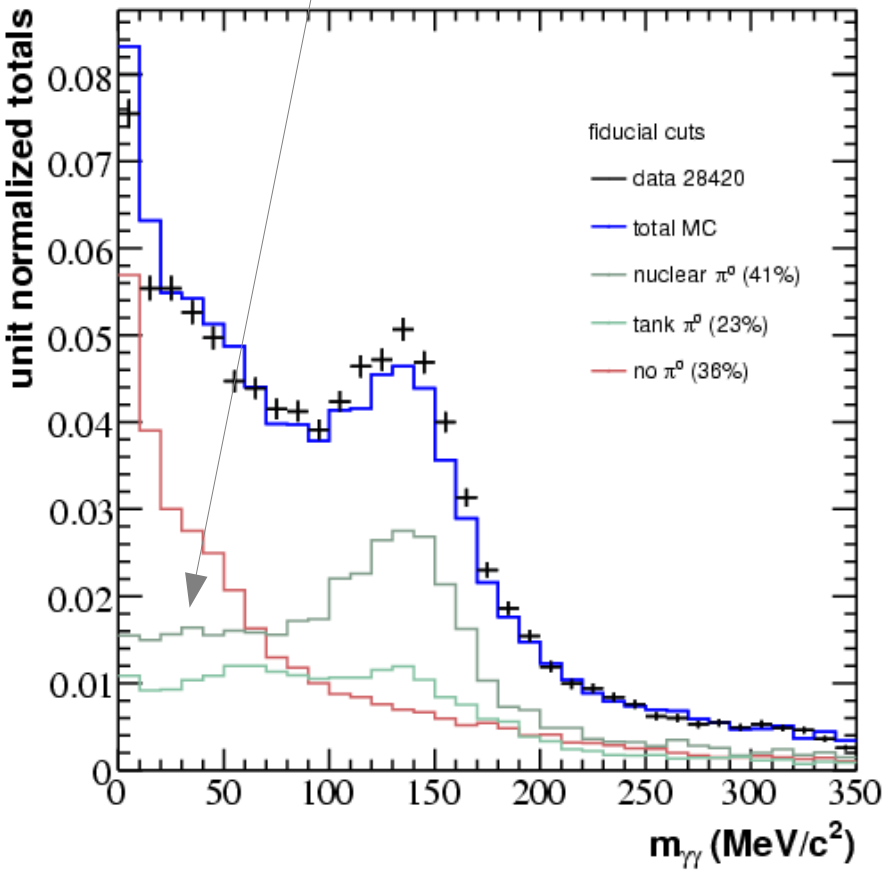


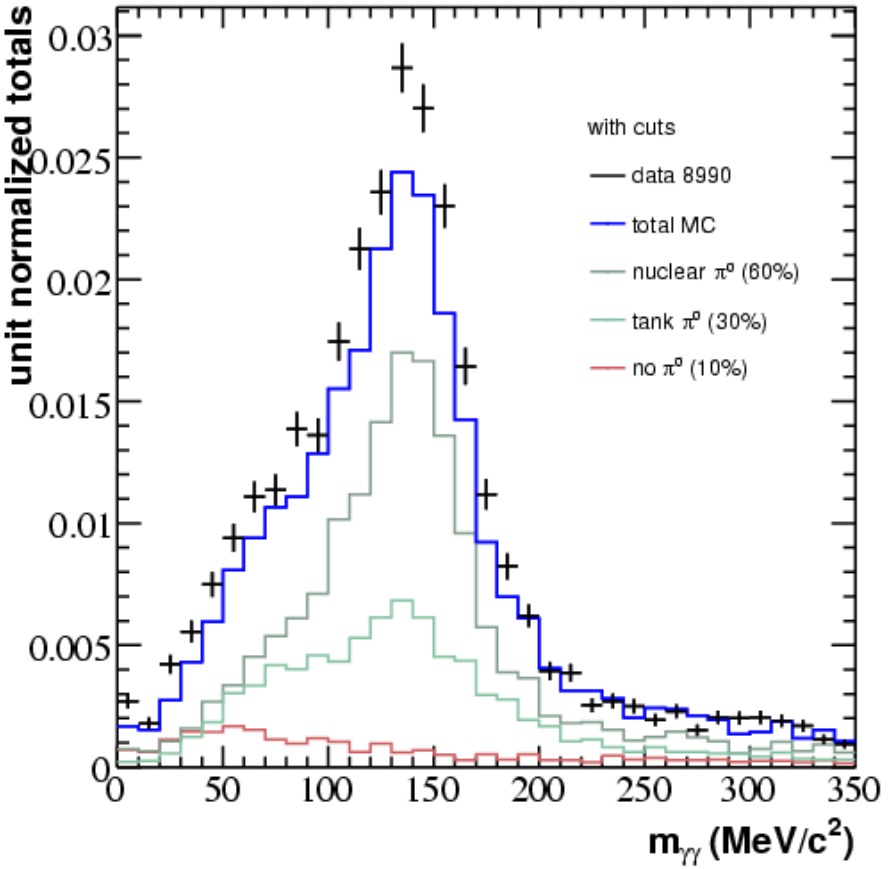




$m_{\gamma\gamma}$

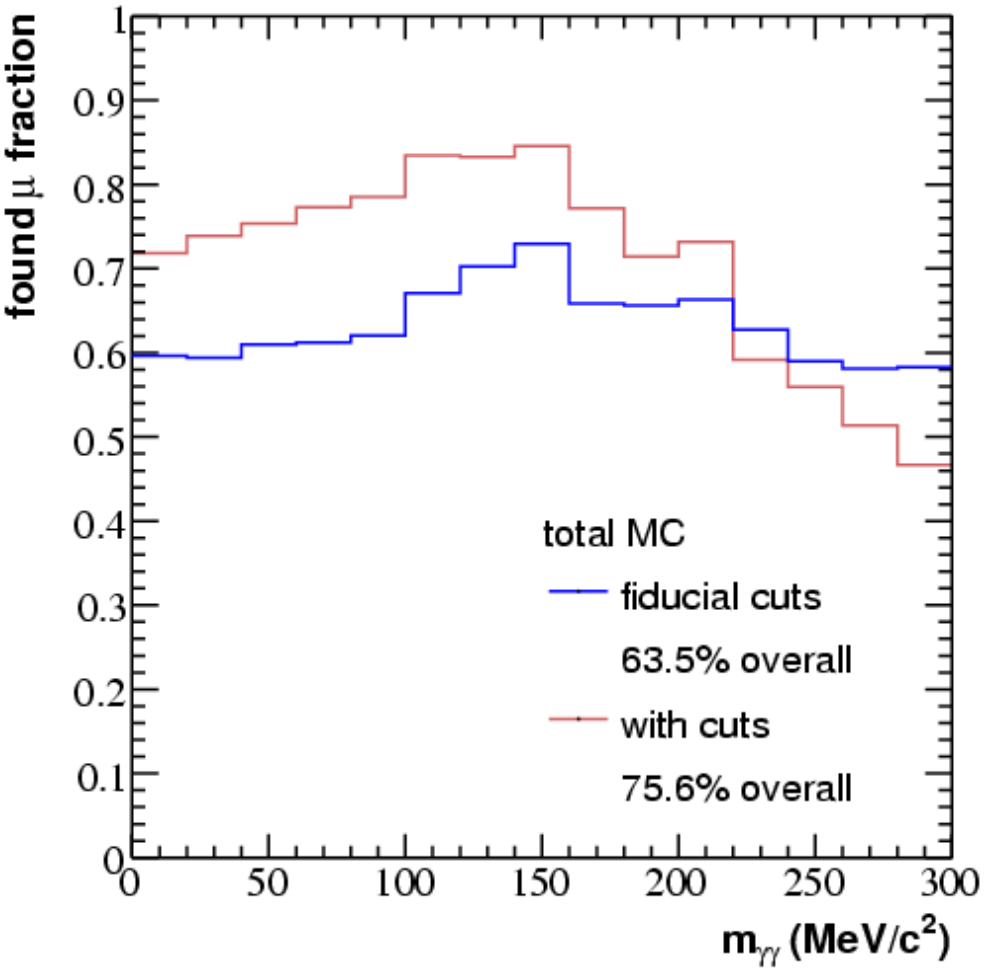
- Cuts on reconstructed quantities are able to draw out the π^0 peak, and improve both muon finding and effective CCπ^0 purity.
- Largest background are the tank π^0. The non-π^0 events have almost been eliminated.
- Odd plateauing of nuclear π^0 at low mass. Clearly a reconstruction issue. Using the overlap of both fit selections should fix this.





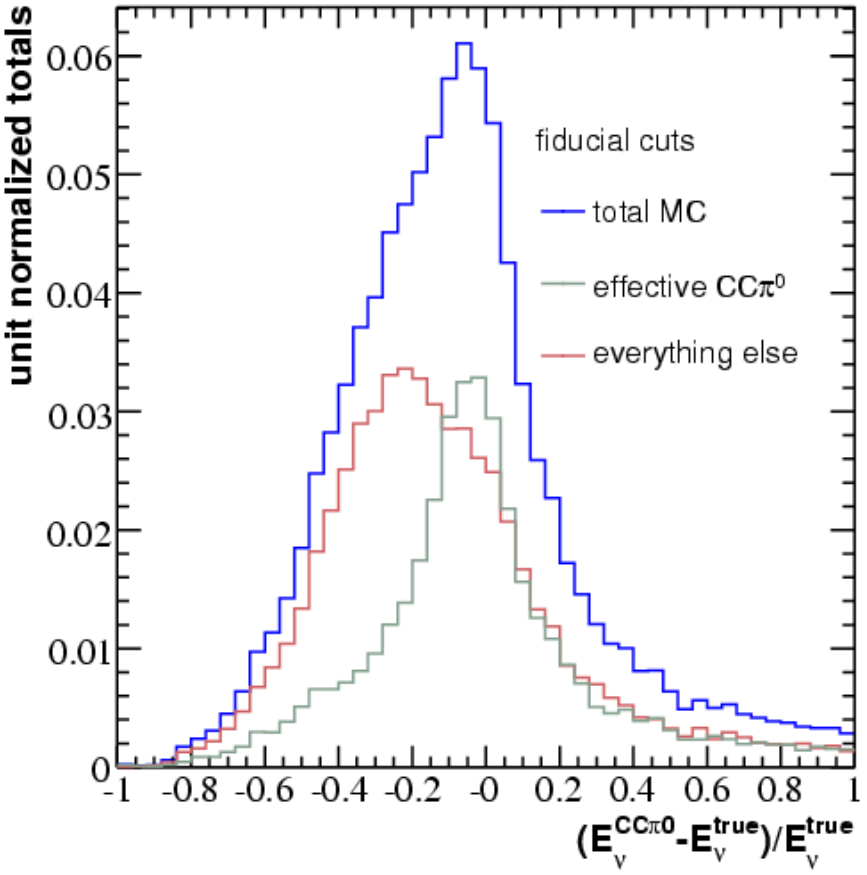
Found μ fraction

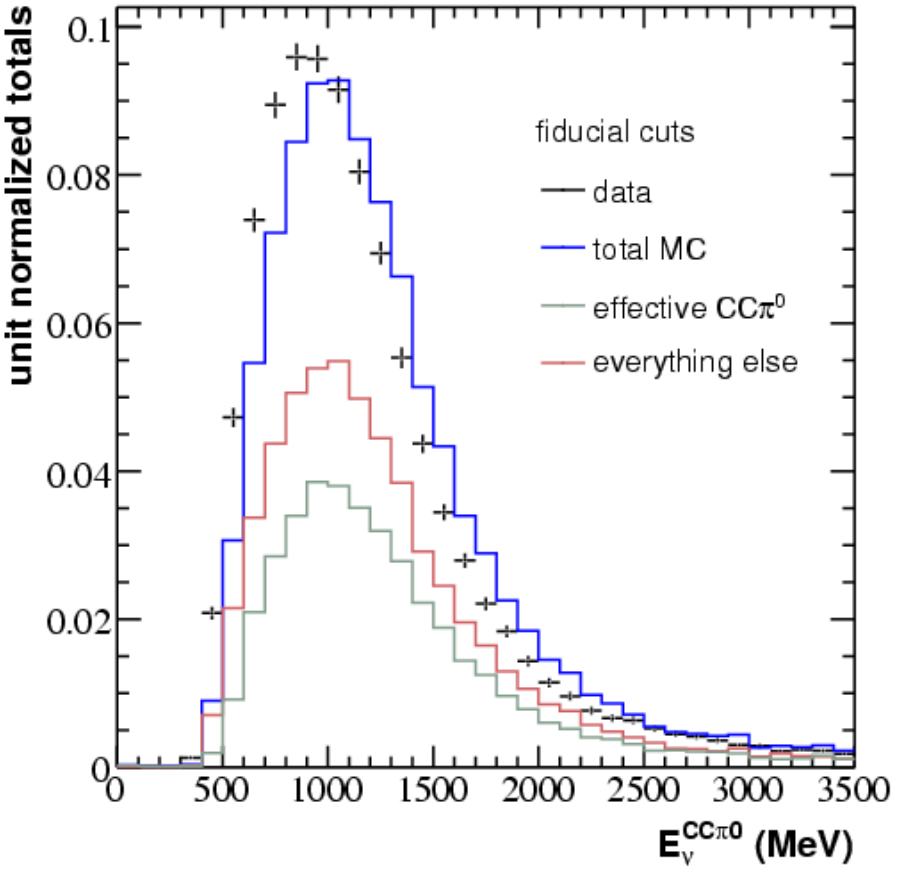
- This fitter, by construction, finds the μ significantly better overall than the original raw likelihood fitter.
- The raw likelihood found it 54% of the time.
- Punishing the likelihood by the michel improves the overall fraction to 63.5%.
- The fraction peaks around the π^0 peak.
- After cuts the peak region is over 80%.



$E_\nu^{CC\pi^0}$

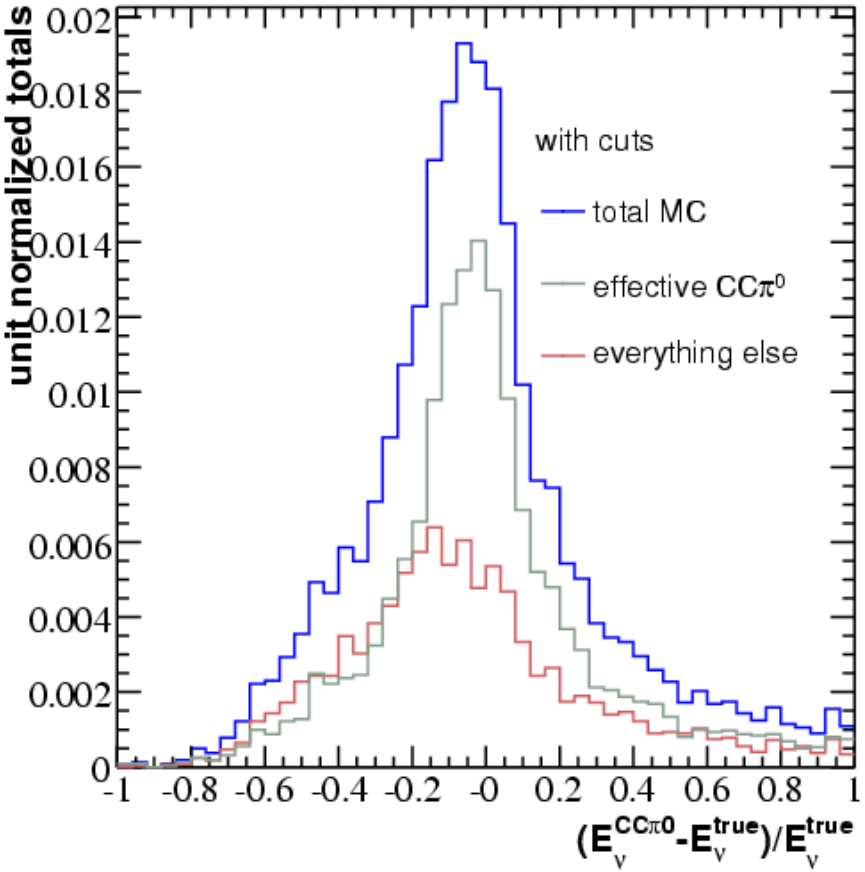
- The energy is only well defined as a reconstructed quantity for effective events, everything else are backgrounds.
- Data and MC show a slight energy shift.
- Effectives reconstruct well, non-effectives reconstructed systematically low.

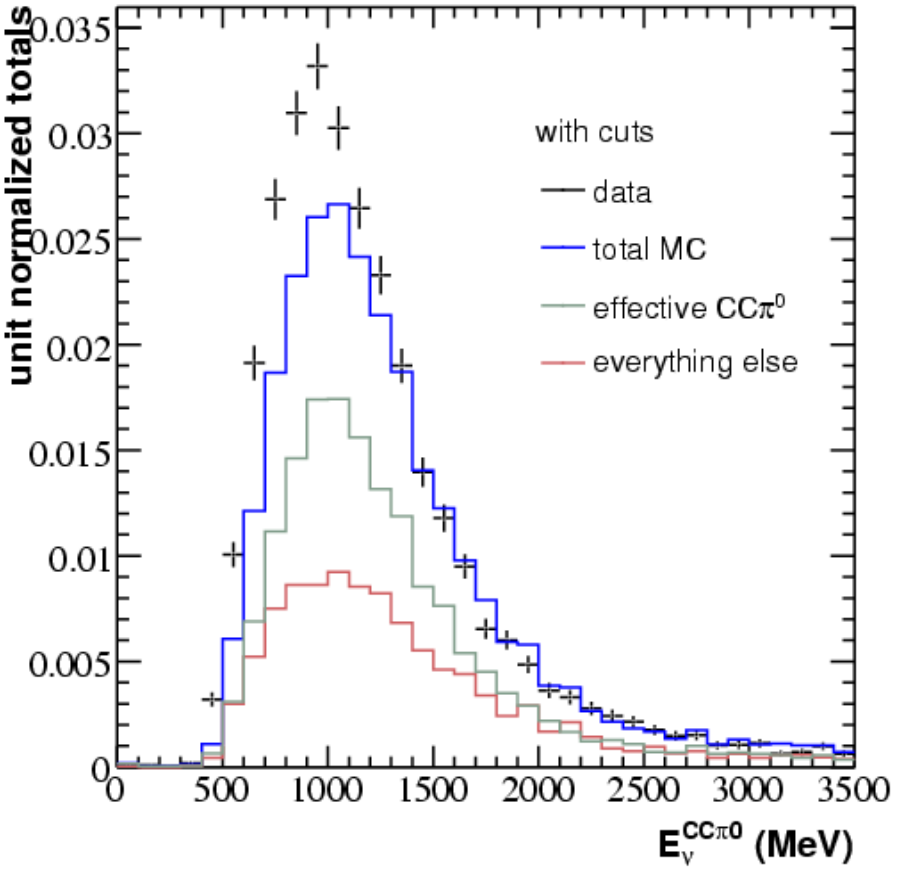




$E_\nu^{CC\pi^0}$

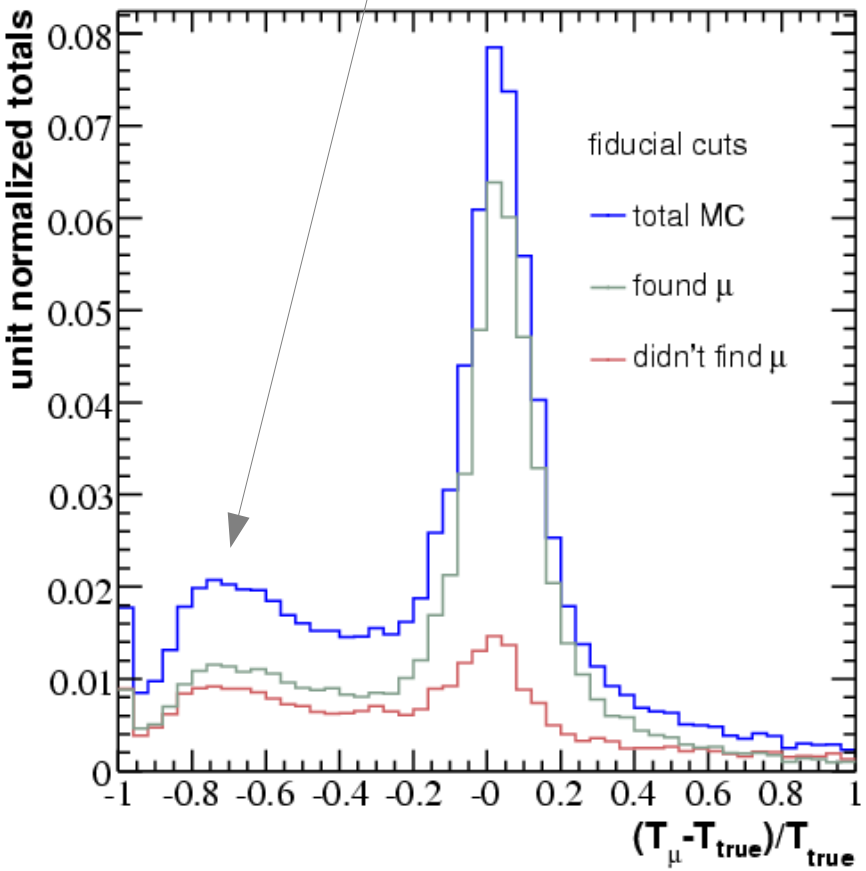
- The cuts are only significant here in that they reduce the amount of non-effectives in the total sample.
- Energy resolution gets slightly better.

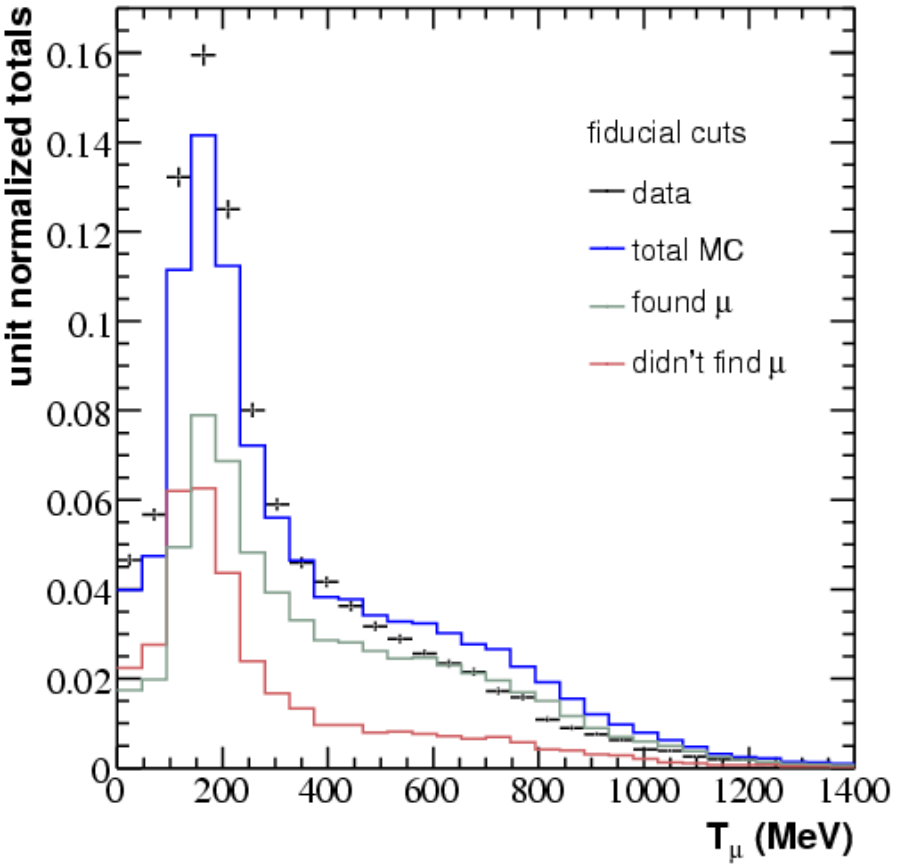




T_μ

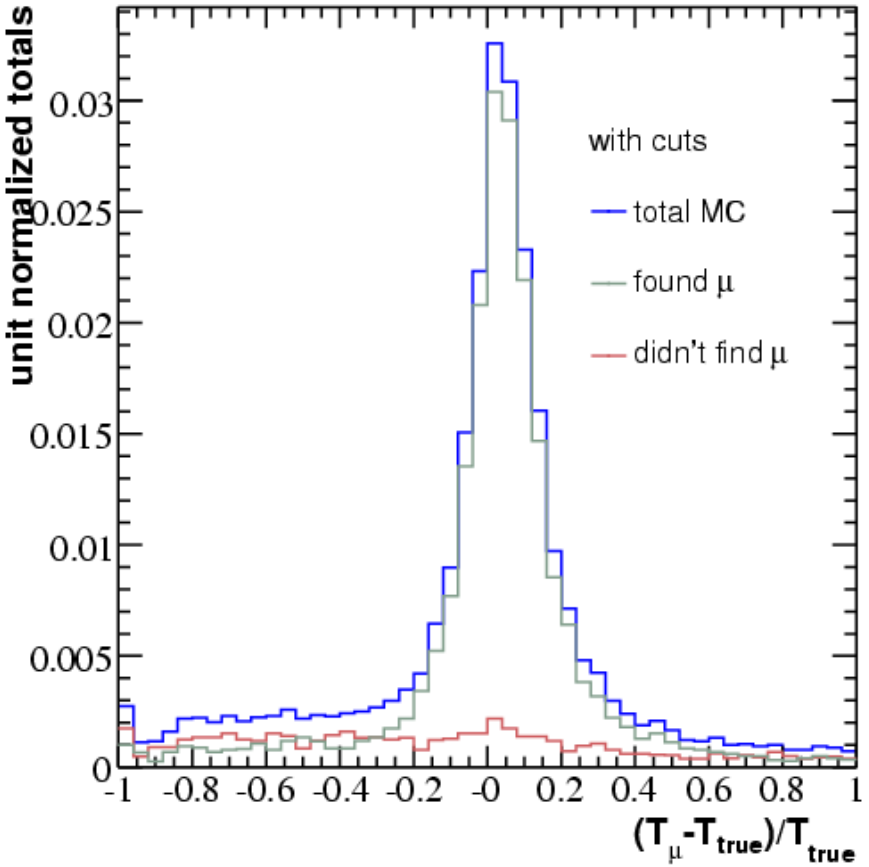
- The peak at 0 for not-found events might show a problem with our definition of found μ.
- Data shows that it might have a higher mis-ID rate.
- Shows the effect of discrete mis-reconstruction.

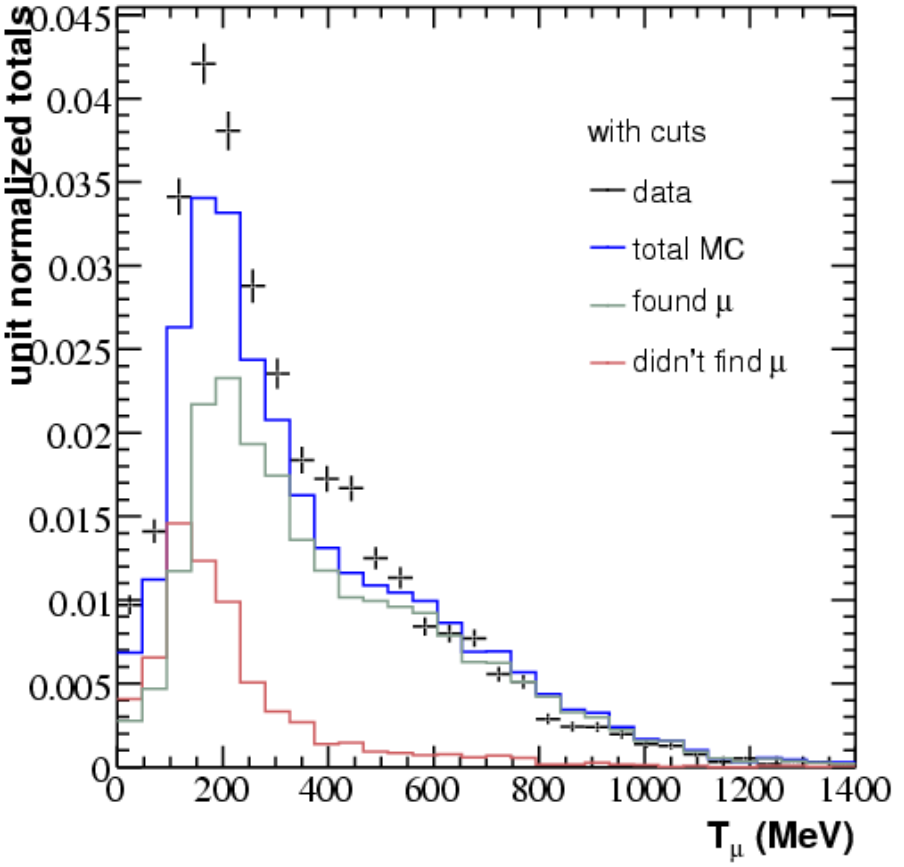




T_μ

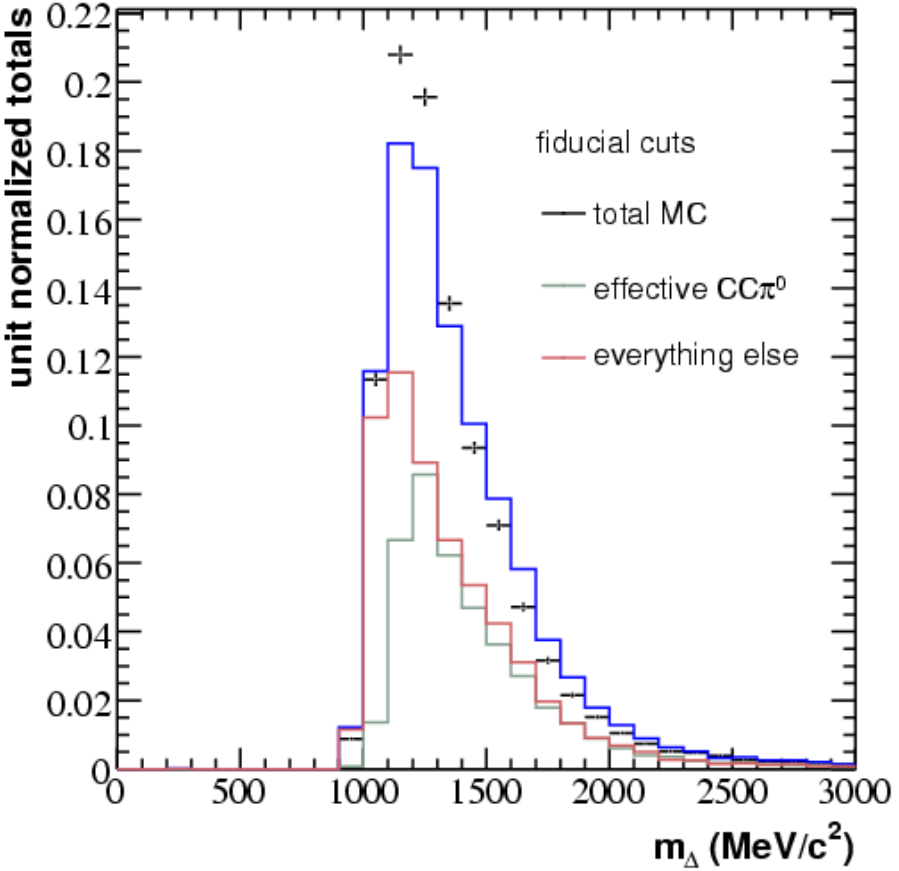
- The mis-IDs show a similar effect to the mis-ID muons in the CCπ^+ two-track analysis where they pileup at lower muon energies.

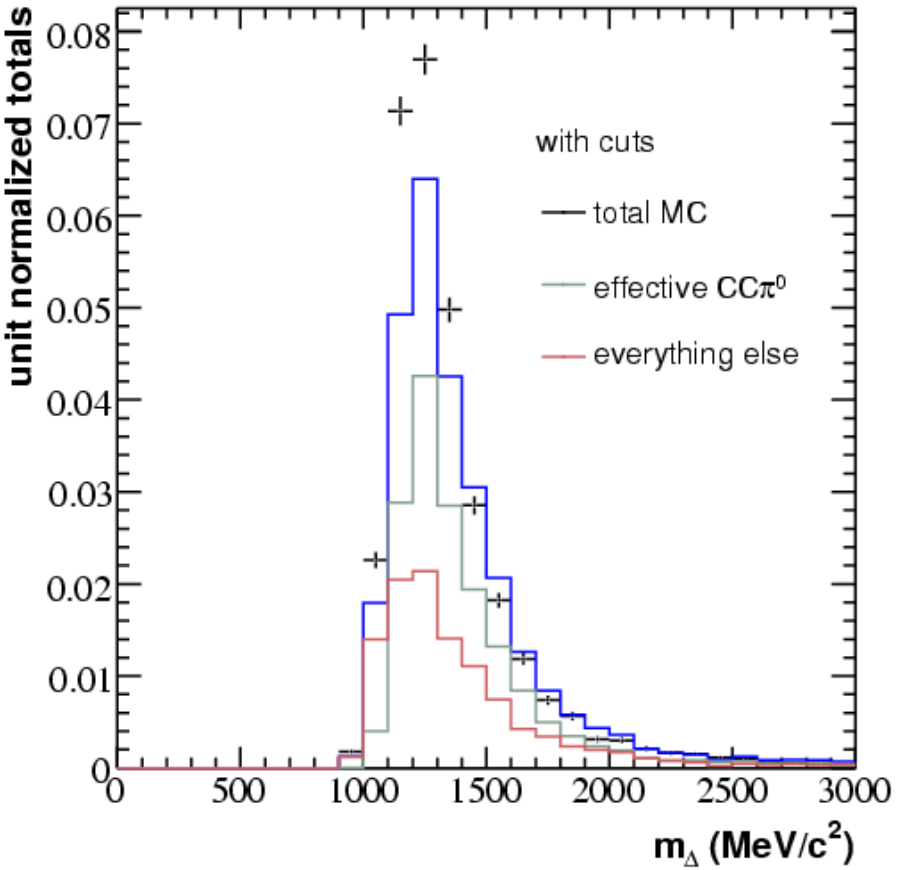




m_{Δ}

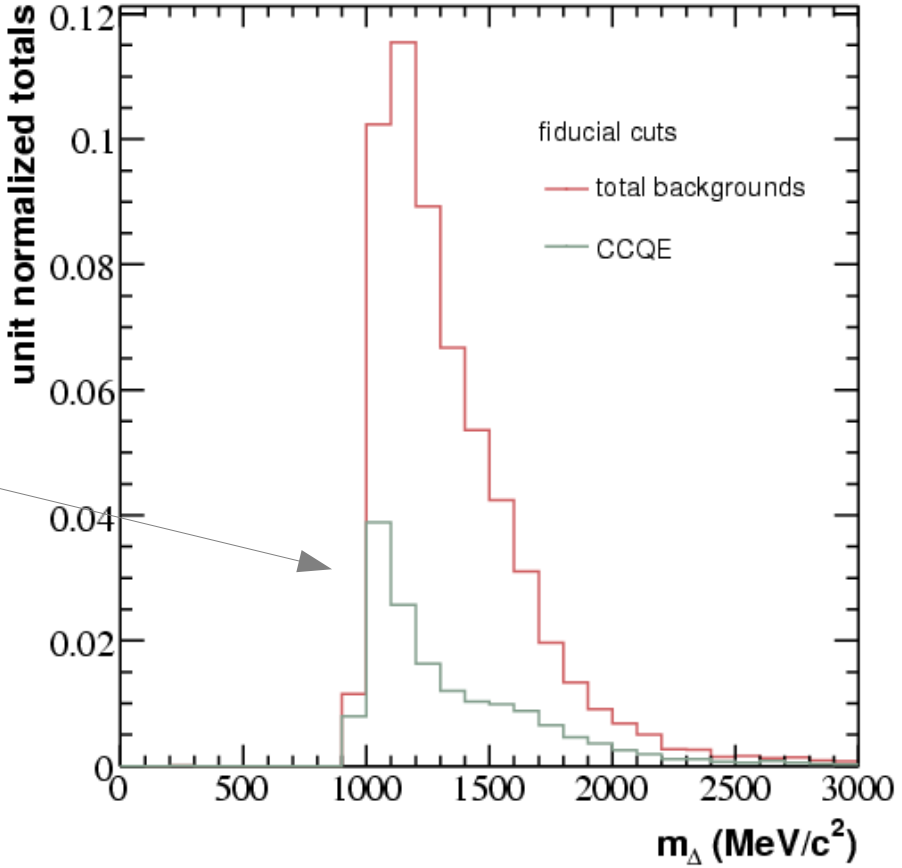
- Nothing shocking here, reconstructs at the delta mass





m_Δ backgrounds

- CCQE pileup at threshold like we'd expect.



To do..

- Run the fits on everything (Data, CV, multisims, may06).
- The fitter we're running on the multisims gives us the option to use any combination of selection criteria.
- Optimize the selection cuts to reduce biases and increase signal efficiency.
- Finish the CCπ^0 reconstruction technote.
- Submit final plots for approval.

NUINT09

10 minute invited talk on the charged current neutral pion cross-section during the single pion session.

First time this will be shown in public

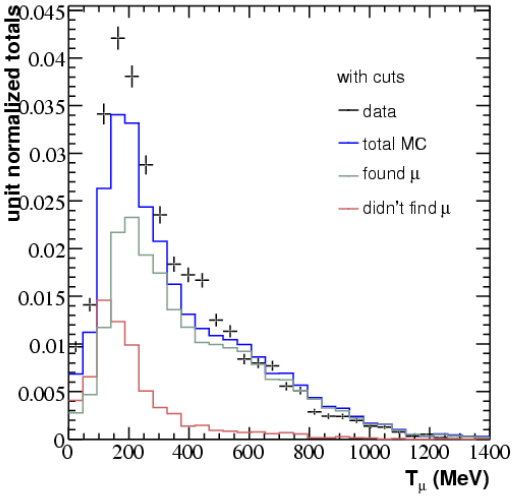
What I plan to talk about

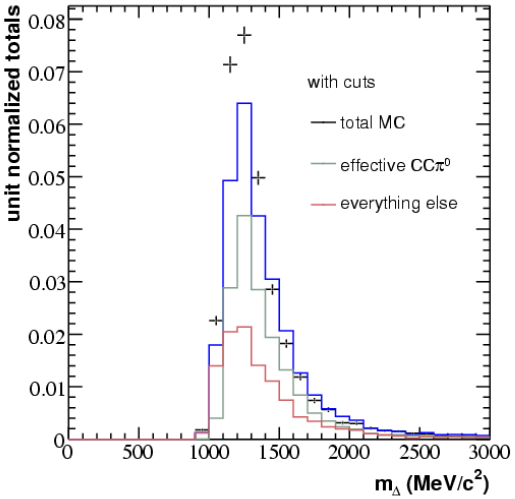
- Goal is to show the feasibility and advertise this measurement.

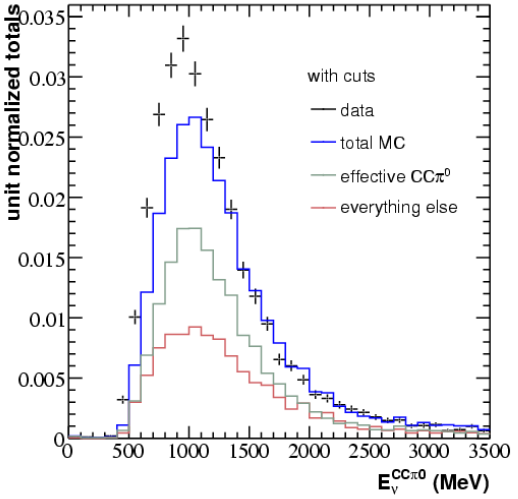
- A description of the CCπ^0 fitter.
- Discussion of the event sample and pre-cuts.
- Definition of effective CCπ^0 events.
- Backgrounds.
- Errors.
  - We hope to have a lot of these ready, but that is based on how fast they can be processed between now and then.

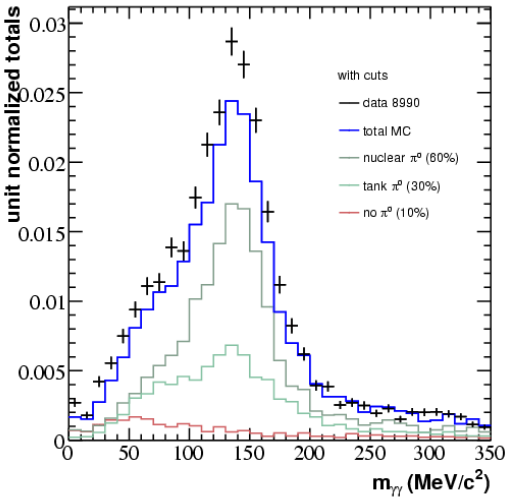
What I plan to show (not these exact plots)

- Comparisons between MC and Data (properly normalized):
  - Basic kinematic distributions:
    - μ kinetic energy and possibly angle.
    - $m_{\gamma\gamma}$, $|p_{\pi}|$, pion angle.
    - Neutrino energy.
    - Delta mass.









What I do not plan on showing

- Q^2
  - There is too much physics in this to show unless we have full errors.
- Cross-sections or cross-section ratios.
  - ditto